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Novel Microfluidic Experiments Of Investigating Permeability Impairment due to Clogging in Rough Fractures

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Fractures commonly compromise rock integrity, emerging as a primary factor in leakage within CO₂ geological storage. Injecting CO₂ into deep saline formations often induces salt precipitation (Evaporation-induced) and mineral precipitation (Chemically-induced), leading to the obstruction of fractures and impairment of reservoir permeability. To assess these effects, we devised a novel microfluidic fracture model using PMMA and rough glass. Two distinct precipitation experiments were conducted: 1) Dry CO₂ is injected at different flow rates into a brine-filled microfluidic model to address the progression of salt precipitation induced by evaporation. 2)Na₂CO₃ and CaCl₂ are concurrently injected at different flow rates into the microfluidic fracture model to prompt mineral precipitation. Utilizing confocal laser scanning microscopy, we identified two salt precipitation modes: large bulk salt crystals and polycrystalline structures. Large bulk salt crystals lead to complete clogging, markedly diminishing fracture permeability. Flow velocity significantly influences the precipitation pattern of mineral precipitation. At high velocity, a more constricted barrier is observed, restricting mixing and reactive transport. Conversely, at low velocity, a broader precipitation zone formed, significantly reducing fracture permeability. This study enhances our comprehension of the blocking behavior of two distinct precipitation in fractures during the CO₂ geological storage.

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